



*... FROM CONCEPT TO PRODUCTION*

# Quantum-Tecstar Overview

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**August 2005**

# Corporate Overview

## **World Leader in Hydrogen Fuel Systems**

Over 45 Years of Gaseous Fuel Experience in Storage, Metering, & Electronic Controls:

- Transportation: Commercial & Military
- Power Generation
- Hydrogen Refueling Infrastructure

## **Acquired Tecstar Automotive Group in 2005**

Largest Tier I Second Stage Manufacturer for GM, Supplier of the Year in 1999

- Second Stage Manufacturing
- Powertrain Engineering
- Systems Integration
- Concept & Specialty Vehicles Development

## **Commercialization Partnerships**

- GM: Worldwide
- Sumitomo: Japan
- IMPCO: Europe
- AM General: North America

**700 Employees, 17 Facilities**

# Industries & Products

## Automotive



### *Clean Propulsion Systems*

- Hydrogen
- Alternative Fuel
- Hybrid Electric



### *Mainstream Automotive*

- Concept Vehicles
- Second Stage OEM Mfg
- Performance & Appearance Products



### *Hydrogen Refueling*

- Mobile & Portable Refueling Systems

## RESEARCH & DEVELOPMENT

## Government



### *Military & Defense*

- Military Vehicle Development



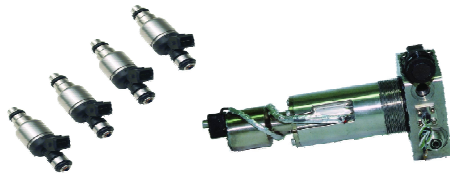
### *Aerospace*

- Lightweight H2 & O2 Systems

# Clean Propulsion Systems



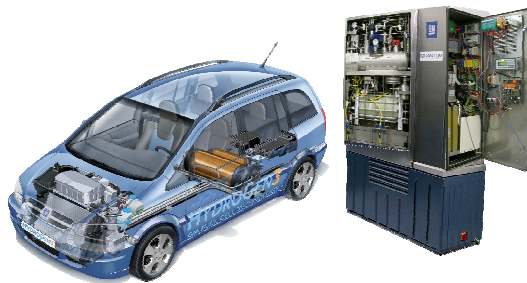
Fuel Storage



Fuel Metering



Electronic Controls



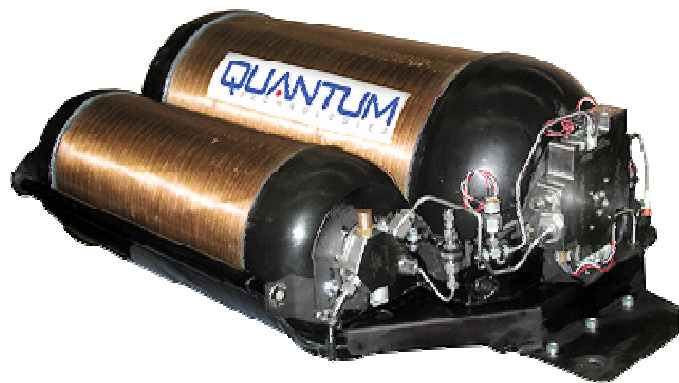
Systems Integration

Hydrogen  
Alternative Fuels  
Hybrid Electric



# Compressed Hydrogen Storage

- Design
- Mechanization
- Validation
- Challenges



*Quantum's compressed hydrogen storage systems used in GM Fuel Cell Vehicles*

# Compressed Hydrogen Storage

## FUEL STORAGE SYSTEMS

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graph TD; A[FUEL STORAGE SYSTEMS] -.- B[TANK]; A -.- C[IN-TANK REGULATOR W/ PRD, TEMP & PRESSURE SENSORS]; A -.- D[SOLENOIDS]; A -.- E[VALVES]; A -.- F[FUEL LINES / TUBING]; A -.- G[ELECTRONICS]; A -.- H[SUPPORT STRUCTURE / BRACKETRY];
```

**TANK**

**IN-TANK REGULATOR  
W/ PRD, TEMP &  
PRESSURE SENSORS**

**SOLENOIDS**

**VALVES**

**FUEL LINES /  
TUBING**

**ELECTRONICS**

**SUPPORT  
STRUCTURE /  
BRACKETRY**



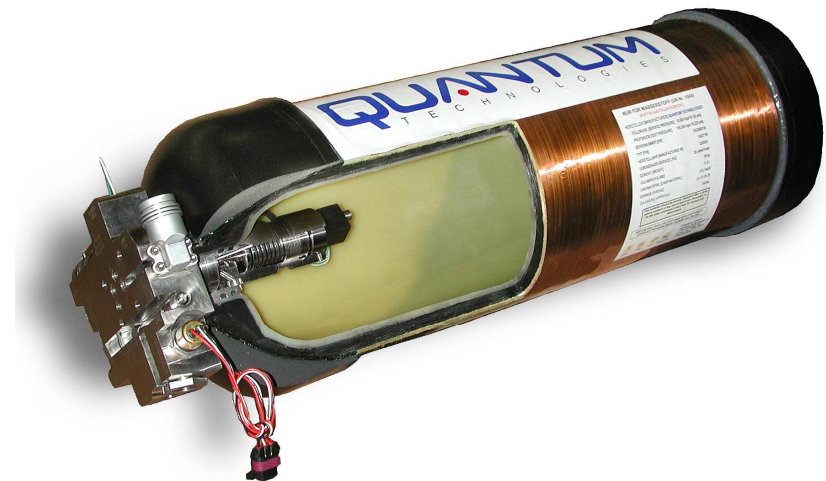
# Fuel Storage & Metering

## TriShield All-Composite Compressed Gas Storage (Type IV)

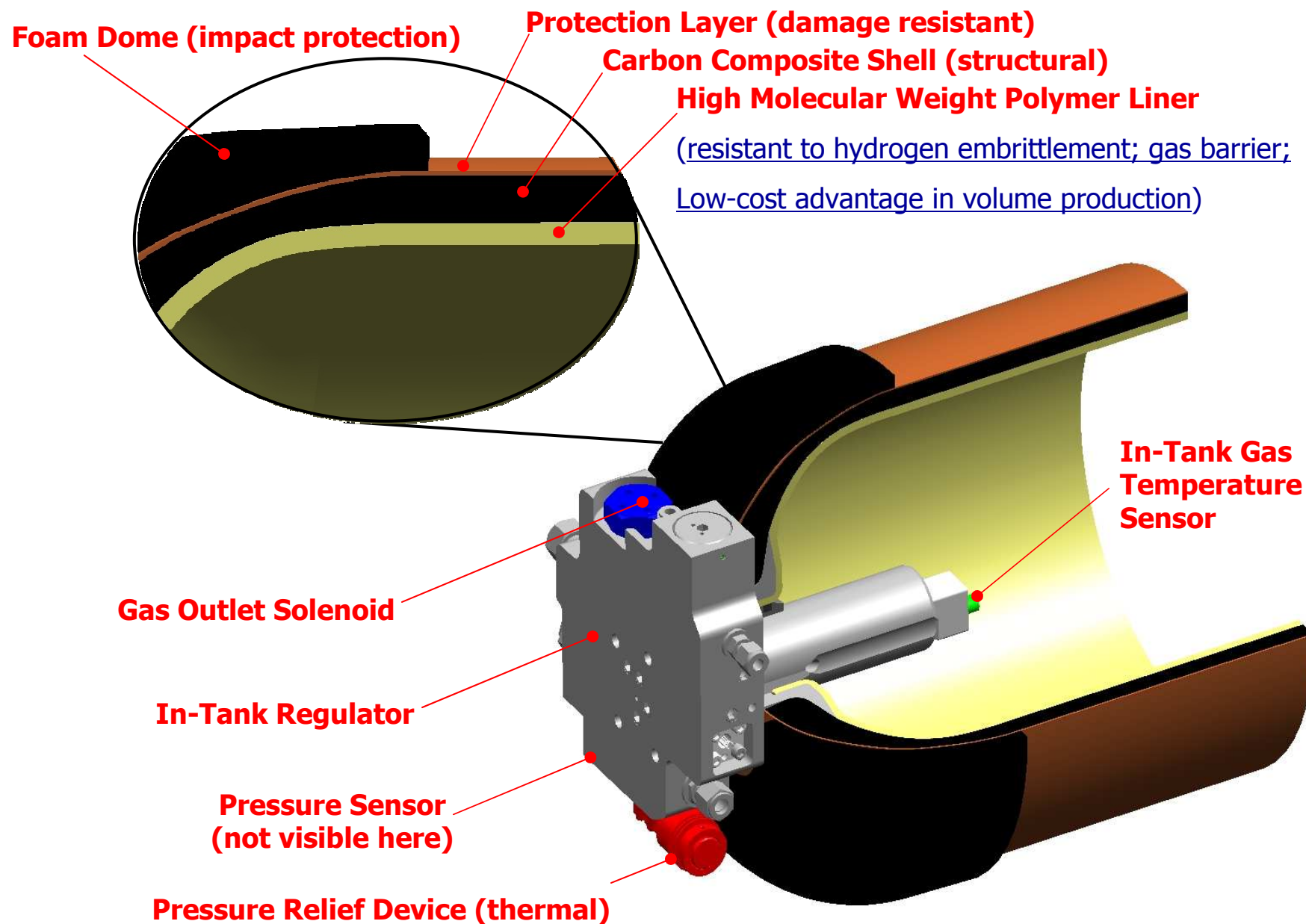
- Hydrogen @ 35 and 70 MPa

## In-Tank High Pressure Regulator

- Designed for 35 and 70 MPa
- Keeps high pressure gas inside the tank, an inherently safer system
- Validation:
  - 35 MPa: EIHP, KHK Japanese High Pressure Vessel Code
  - 70 MPa: EIHP, TÜV German Pressure Vessel Code

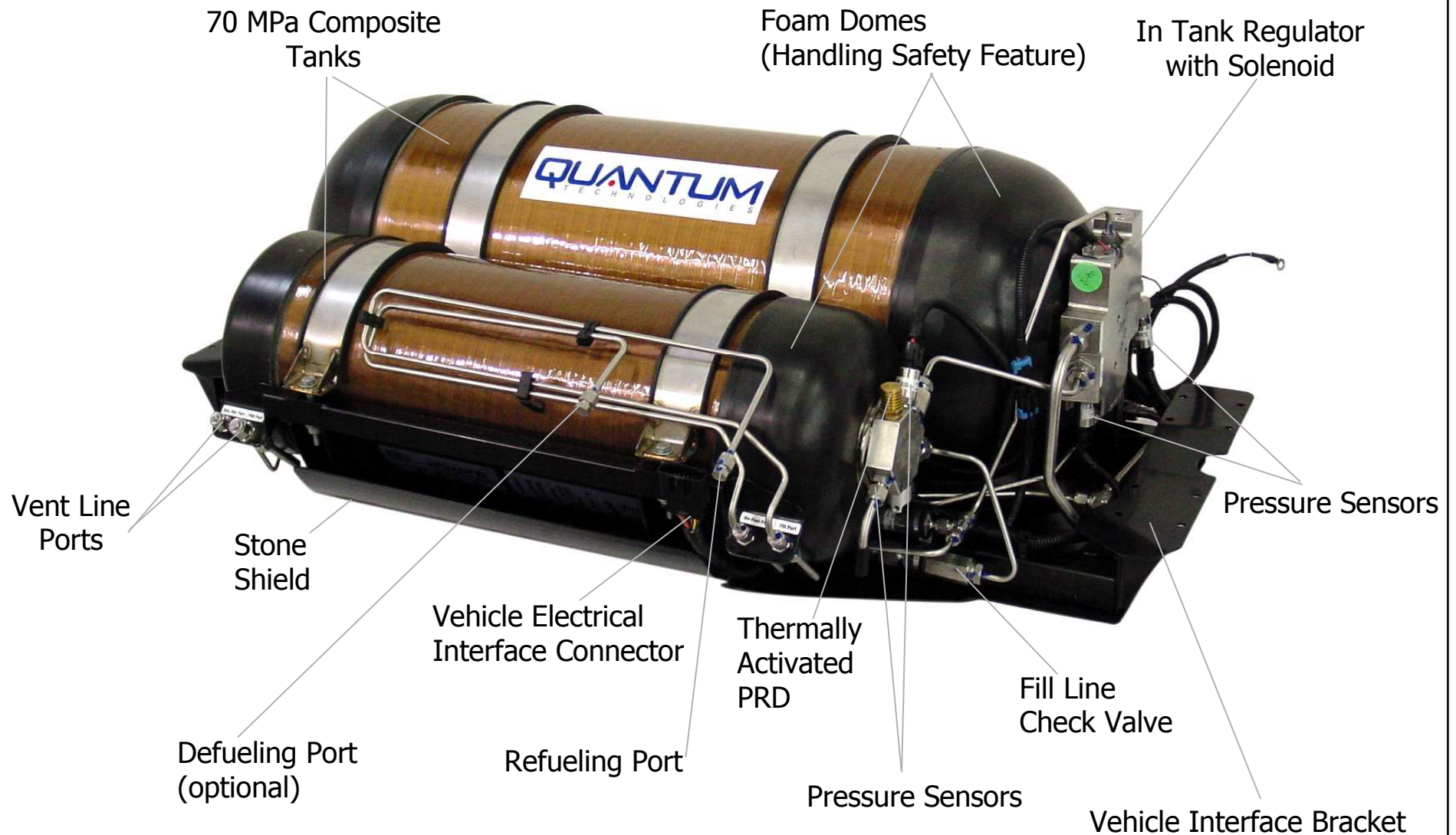


# Quantum TriShield™ Storage Tank

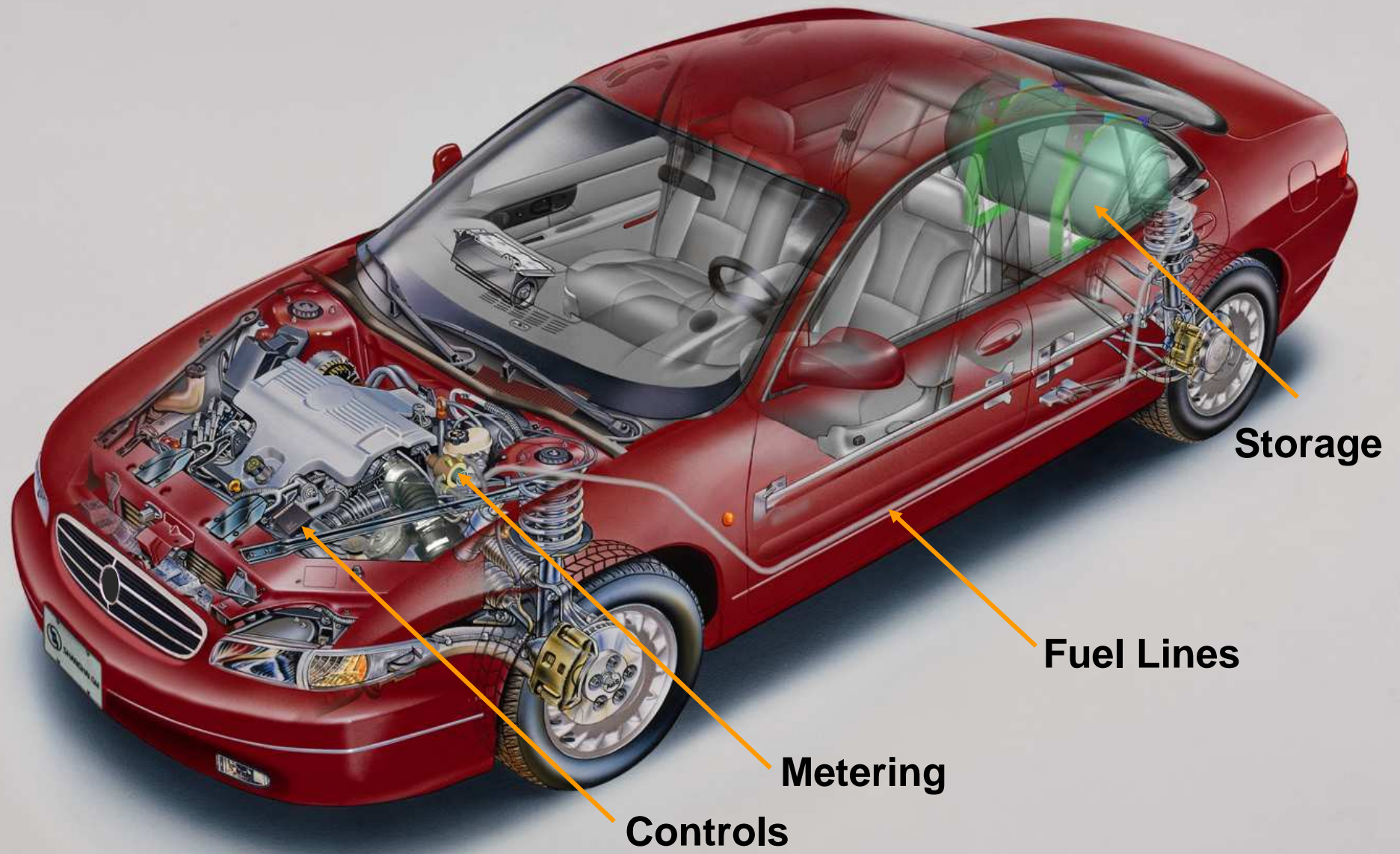




# World's First 70 MPa Hydrogen Fuel Storage System

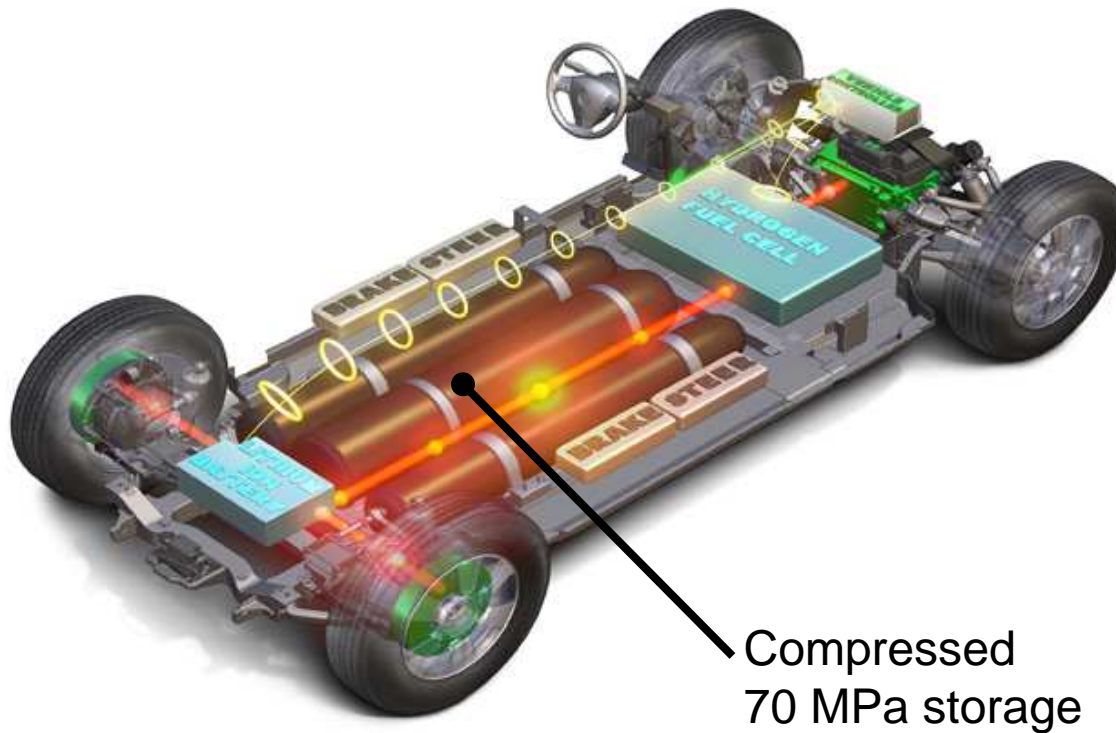


# Typical Compressed Gas Fuel System

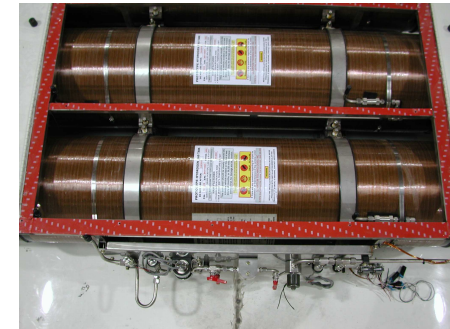
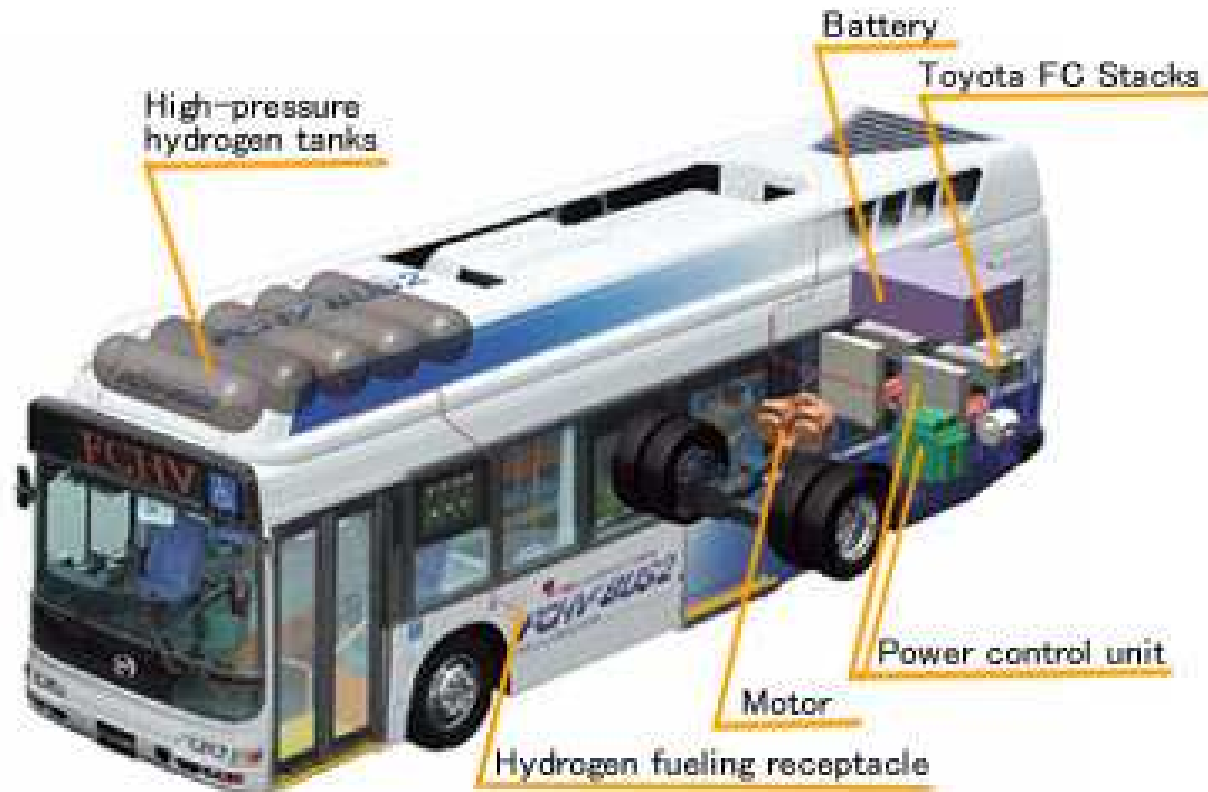




# Future Concepts of Compressed Storage - GM Sequel



# Hydrogen/Hydrogen-Blend Bus Systems



# Compressed Hydrogen Storage - Validation

## Standards

- ISO 15869 International
- NGV2 US/Japan/Mexico
- FMVSS 304 United States
- NFPA 52 United States
- KHK Japan
- CSA B51 Canada
- EIHP Europe
- TÜV Germany

## Validation Tests

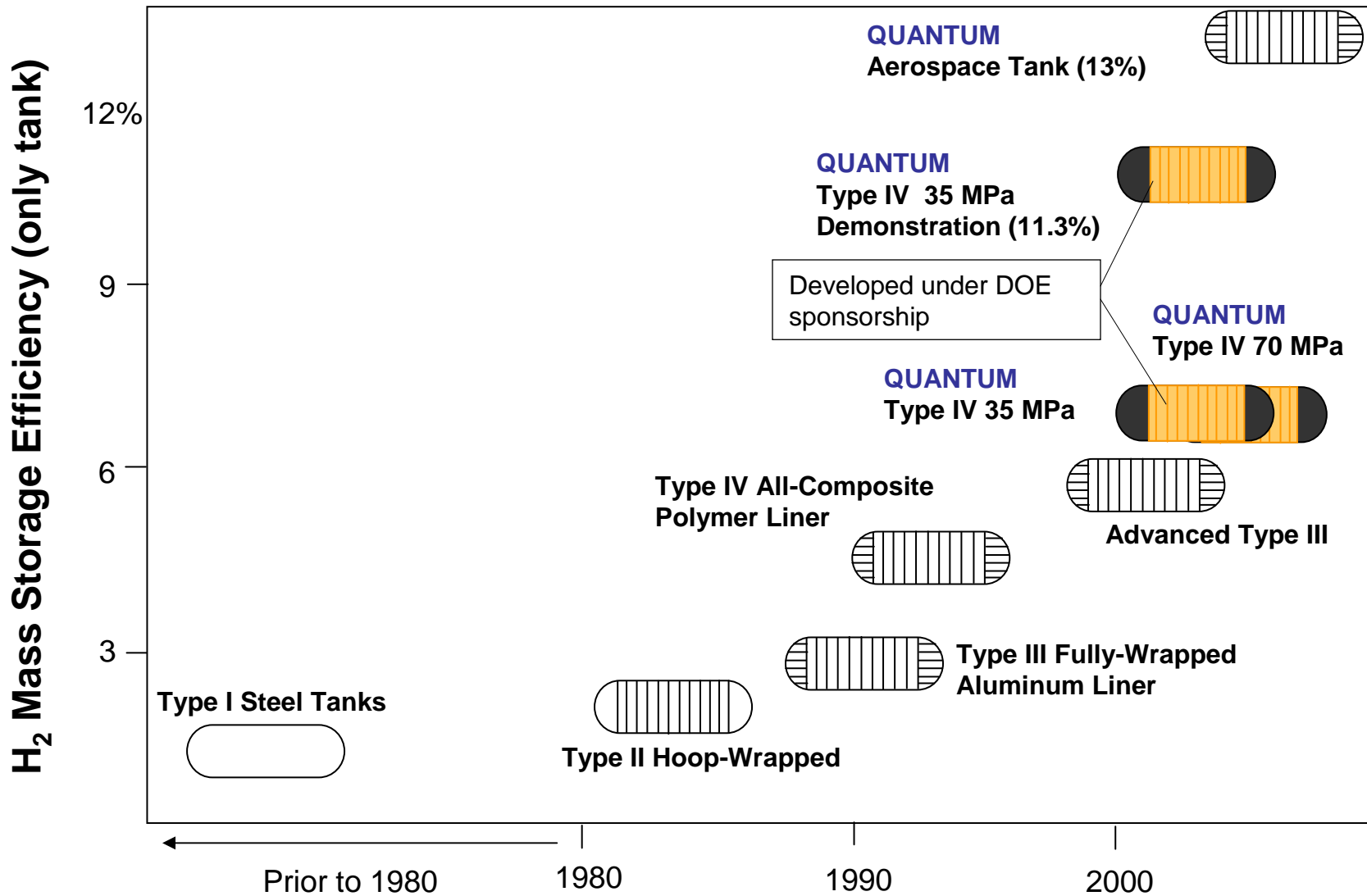
- Hydrostatic burst
- Extreme temperature cycle
- Ambient cycle
- Acid environment
- Bonfire
- Gunfire penetration
- Flaw tolerance
- Accelerated stress
- Drop test
- Permeation
- Hydrogen cycle
- Softening temperature
- Tensile properties
- Resin shear
- Boss end material

# Compressed Hydrogen Storage - Challenges

- Storage capacity
- Safety perception
- Cost



# Compressed Fuel Storage – Quantum Leadership



# Compressed Gases are All Around Us



## Type of Cylinder

Pressures up to  
(in MPa)

Industrial gas	41
Fireman's breathing tank	30
Paintball propellant	30
Natural gas vehicle storage	25
Scuba tanks	23
Medical	21
Aircraft oxygen and emergency slides	21
Beverage	12
Nitrous Oxide (automotive)	8
Fire extinguishers	1.6



# Hydrogen Safety

- Designs based on decades of industrial experience with compressed gases and hydrogen
- Government and industry groups are developing standards

**Safety Standards Will Ensure Safe  
Hydrogen Storage**

# Conclusions

## Safety:

- Codes and standards are being developed for hydrogen storage systems and vehicles fueled by hydrogen
- Testing & validation programs are underway
- Government, industry representatives and automakers are taking active role in hydrogen storage safety
- Off board / refueling infrastructure needs more attention

## Manufacturing / Costs:

- Storage is a significant cost factor in overall fuel cell system cost
- Design & process improvements to address costs are ongoing



... FROM CONCEPT TO PRODUCTION

**Thank you.**  
**[www.qtw.com](http://www.qtw.com)**